JAXA TRMM/GPM Program Status

Riko OKI (JAXA/EORC)

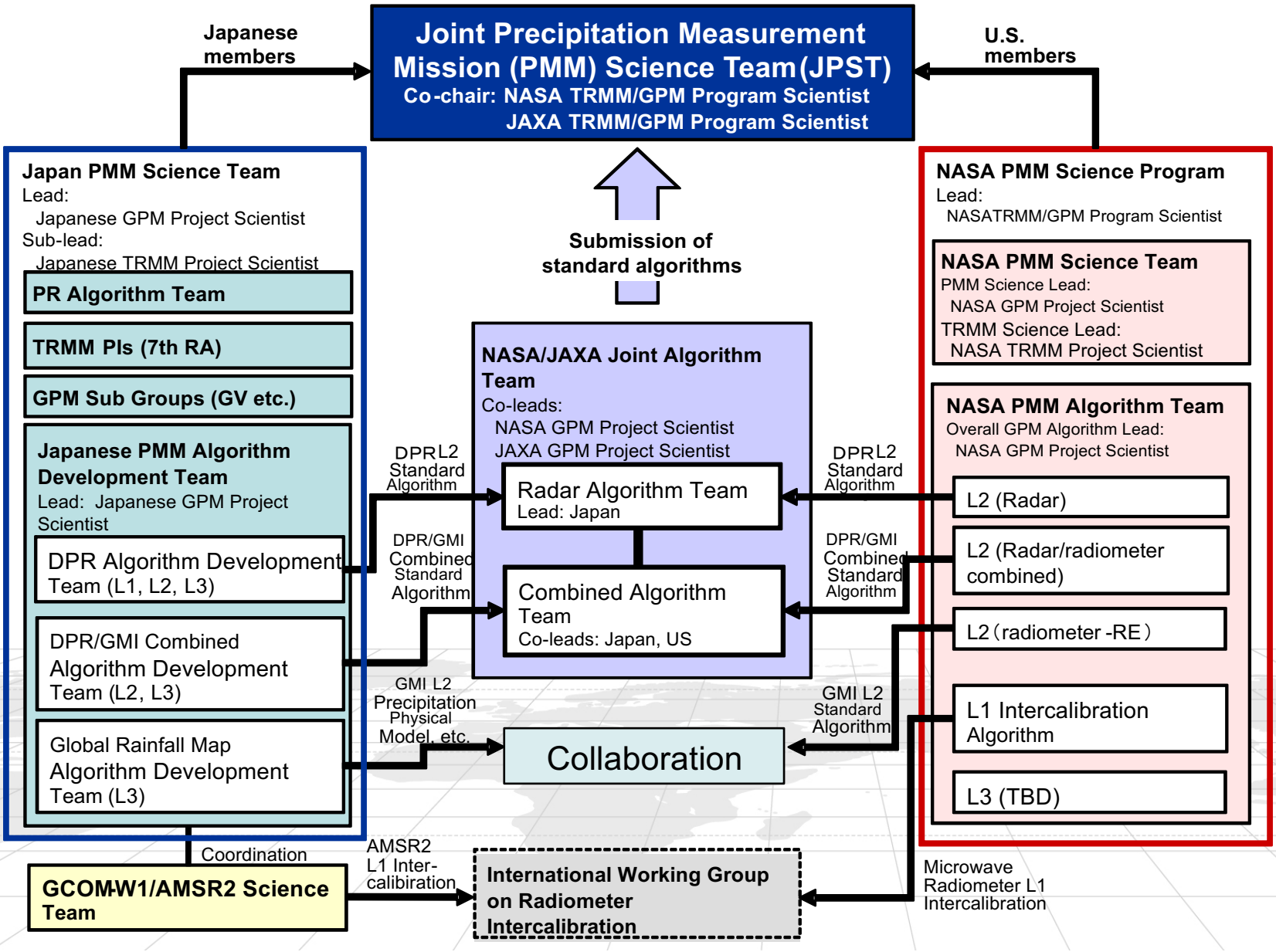
2016 PMM Science Team Meeting, October 2016

Japanese PMM Science Team

- The new Japanese PMM Science Team started in Apr. 2016 for three-year period.
  - 41 proposals for the 8th RA (JFY2016-2018)
    - It is the 8th RA since the first TRMM RA, and the 4th as PMM
    - 30 with research cost proposals
    - 13 no cost transfer proposals including 10 from abroad
  - The science team includes both TRMM and GPM activities.
  - With compared to the previous 7th RA, features of 8th RA are following.
    - Proposal increased: 31 in 7th RA → 41 in 8th RA
    - Abroad PIs increased: 4 in 7th RA → 10 in 8th RA
    - JMA & JMA/MRI PIs joined more (6 proposals in 8th RA)
    - Proposals of “Application” increased: 10 in 7th RA → 14 in 8th RA

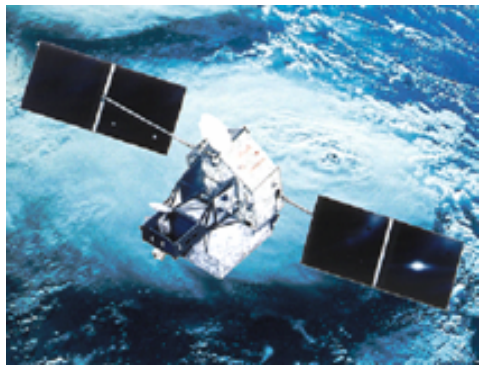
Japan and U.S. PMM Science Framework

-- two joint algorithm development teams --



Tropical Rainfall Measuring Mission (TRMM)

- **Precipitation Radar (PR) onboard the TRMM satellite completed on 1st April 2015.**
- **TRMM re-entered the atmosphere at 12:55 p.m. on June 16, 2015 (Japan Standard Time) over the South Indian Ocean.**
- Major characteristics
  - ✓ Focused on rainfall observation. First instantaneous rainfall observation by three different sensors (PR, TMI, VIRS). PR, active sensor, can observe 3D structure of rainfall.
  - ✓ Targeting tropical and subtropical region, and chose non-sun-synchronous orbit (inc. angle 35 degree) to observe diurnal variation.
- Major achievement in Japan
  - ✓ Demonstration of high quality and high reliability of a satellite onboard precipitation radar
  - ✓ Improvement of precipitation retrieval from passive microwave radiometer by PR 3D observation
  - ✓ Pioneering precipitation system climatology by PR observation



US-Japan joint mission

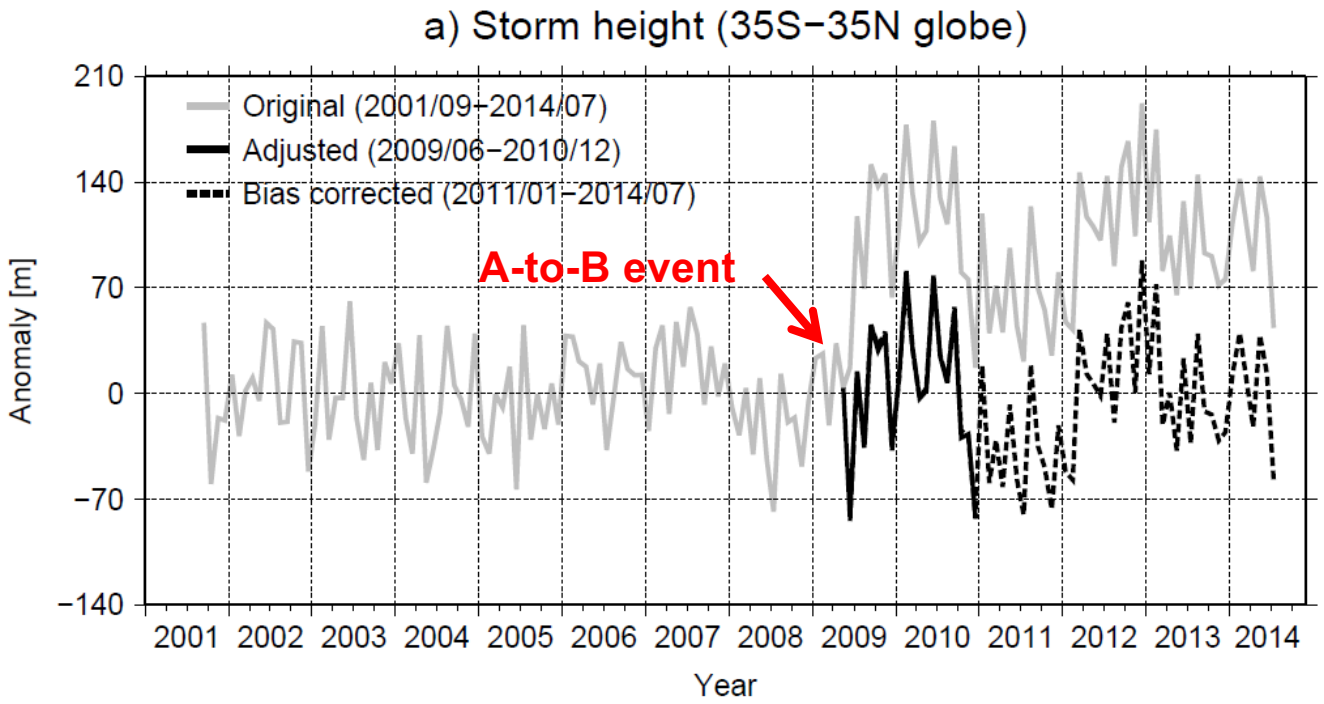
Japan: PR, launch

US: satellite, TMI, VIRS, CERES, LIS, operation

Launch	28 Nov. 1997 (JST)
Altitude	About 350km (since 2001, boosted to 402km to extend mission operation)
Inc. angle	About 35 degree, non-sun-synchronous orbit
Design life	3-year and 2month
Instruments	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS) Lightning Imaging Sensor (LIS) CERES (not in operation)

A development of the TRMM PR Climate Records

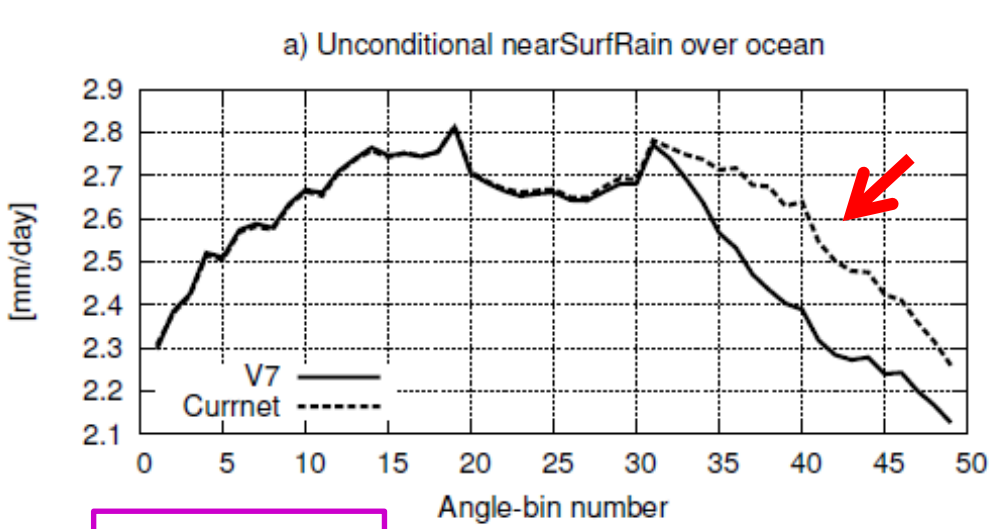
- PR' system was switched from original A-side to the redundant B-side (A-to-B event) at June 2009.
  - We found the jump of PR's sensitivity and developed the mitigation method (~ 1% change for rain estimates)



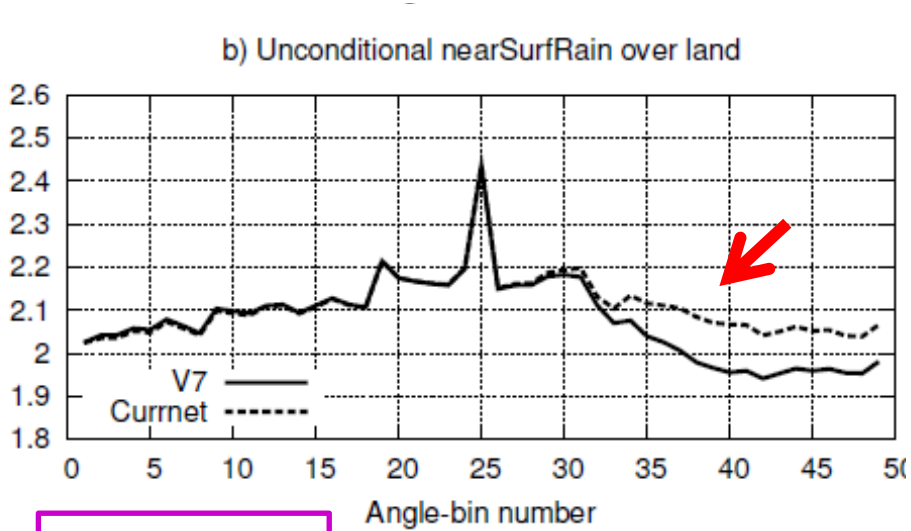
Kanemaru et al. (2016a, in preparation)

A development of the TRMM PR Climate Records

New beam-mismatch correction improves an asymmetry of precipitation estimates found in V7 during pre-boost period.
This improvement mitigates discontinuity caused by the orbit-boost.



Over ocean

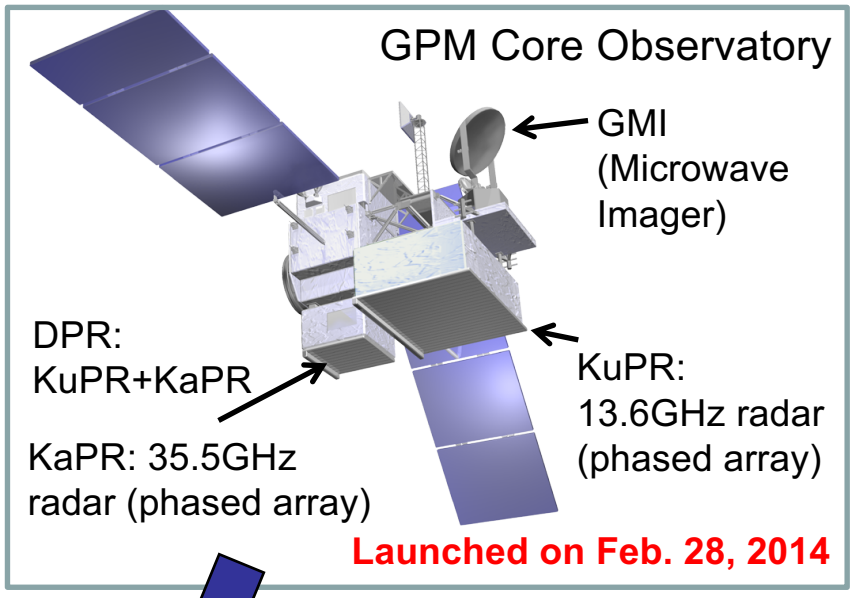


Over land

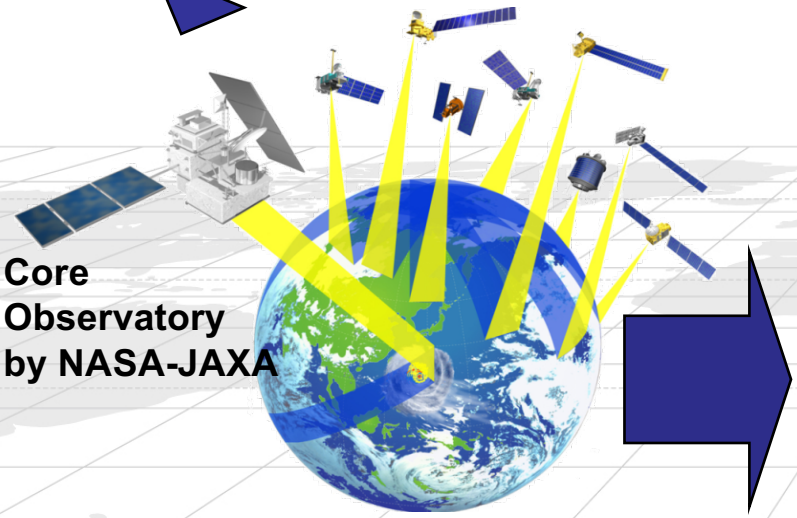
2001/09-2002/08 (1-year) average

Improvement of new correction is evaluated for 96 (73) % mitigating asymmetric bias over oceans (land) after the orbit-boost (*Kanemaru et al., 2016b, in preparation*).

Global Precipitation Measurement (GPM)

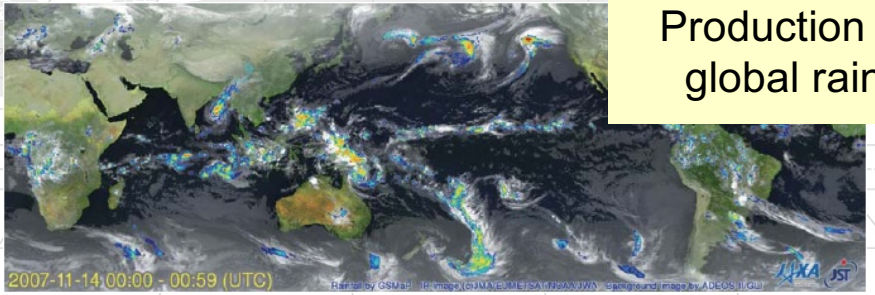


Constellation satellites by international partners



Core Observatory by NASA-JAXA

- Knowledge regarding climate variations
  - Continuous precipitation observation data from TRMM to GPM
- Highly reliable knowledge regarding precipitation science
  - Observation of cumulonimbus, tropical cyclones, diurnal variations of precipitation in the tropics
  - →Observation of precipitation over the mid-to-high latitude frontal zones
- Near-real-time precipitation information
  - For numerical weather prediction
  - For flood alert/warning system, etc.

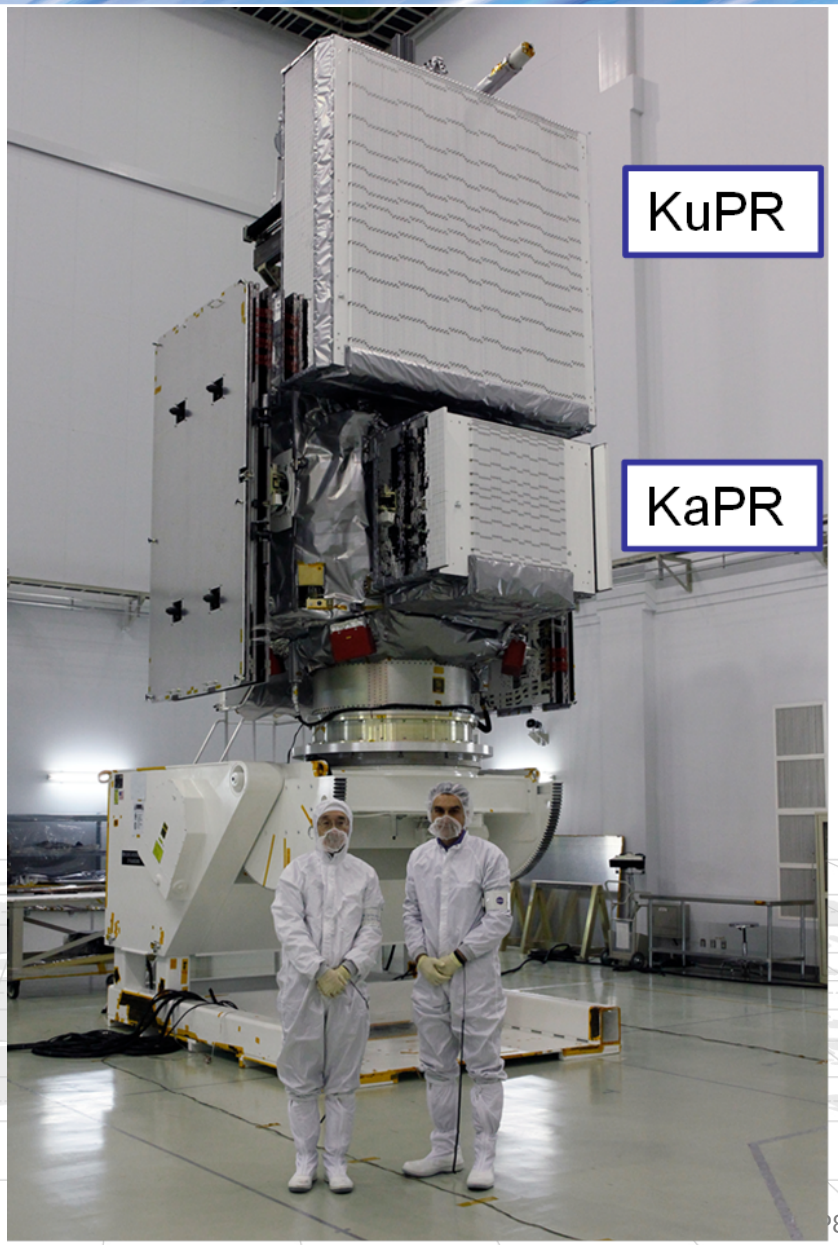


Production of hourly global rainfall map

DPR Sensor Status

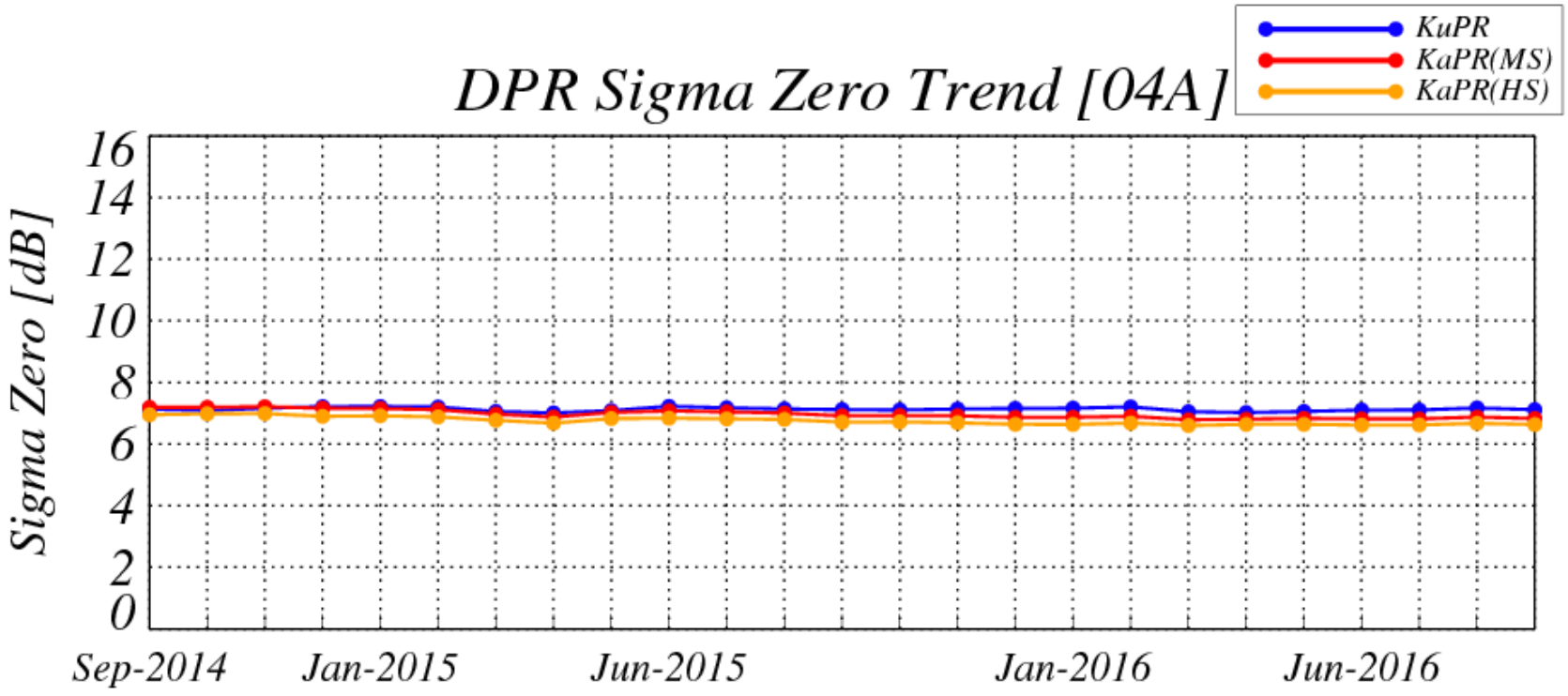
- JAXA is continuing DPR data monitoring to confirm that DPR function and performance are kept on orbit.
  - Operation Mode
  - Temperature
  - Bus Voltage and Current
  - System Noise
  - Sea Surface Radar Cross Section (σ0)
  - Internal Calibration
    - ～1 time / week
  - External Calibration
    - 2 periods / year (～5 times / period)
  - TX/RX Amplifier Status
    - 2 times / year

DPR data monitoring results show that there is no degradation of DPR function and performance from Launch till now.



Trends of DPR σ^0 statistics

- Trends of DPR σ^0 statistics have been stable.
- DPR has observed normally without any problems in both transmitter and receiver system.



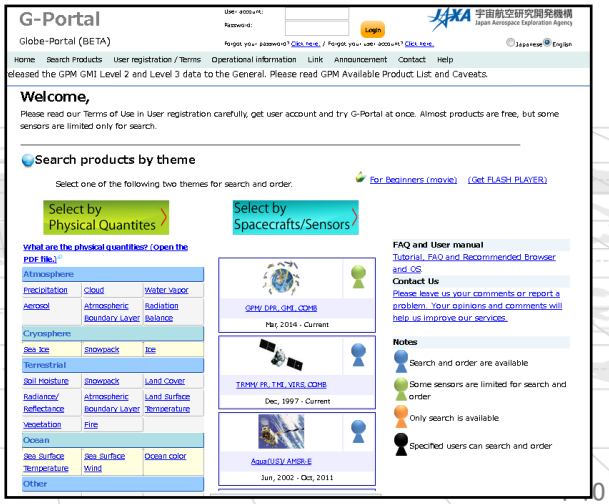
NOTE:
- These statistics values are monthly average over ocean.

GPM/DPR Ground System Status

- JAXA Mission operations System (MOS) operation is normal.
- Data latency statistics (from observation start to JAXA/MOS readiness time for distribution) monitored by JAXA is shown below;
  - GMI L1B : approx. 20 min (>99%)
  - DPR L2 : approx. 1 hr 10 min (>99%)
  - COMB L2 : approx. 1hr 20 min (>99%)
- → GPM data can be used by operational agencies timely.

- You can get GPM data from JAXA/G-Portal.
- https://www.gportal.jaxa.jp/gp/top.html

Data search interface (GUI) and SFTP direct access are available.



GPM Algorithm Development Status (Summary)

- DPR Level 1 algorithm (JAXA)
  - V04 product was released in March 2016.
  - V05 algorithm was submitted to JAXA SAOC on Jun. 2016. (and will be released on Spring 2017).
- DPR Level 2 and 3 algorithm (Joint Japan-U.S.)
  - V04 product was released in March 2016.
  - V05 algorithm will be submitted to JAXA SAOC and NASA PPS in Nov. 2016 (and will be released on Spring 2017).
- DPR/GMI combined Level 2 algorithm (Joint Japan-U.S.)
  - V04 product was released in March 2016.
  - V05 algorithm will be submitted to NASA PPS in Dec. 2016 (and will be released on Spring 2017).
- DPR Latent heating algorithm (Japan-U.S.)
  - V04 product was released in March 2016.
  - V05 algorithm will be submitted to JAXA SAOC and NASA PPS in Mar. 2017 (and will be released on Spring/Summer 2017).
- Global Rainfall Map algorithm [GSMaP] (Japan)
  - Minor version upgrades (V03B to V03F).
  - V04 Product will be release on December 2016.

Calibration change of GPM/DPR and TRMM/PR(1/2)

- GPM/DPR's and TRMM/PR's calibration factors will be changed in V05 based on the new calibration results.
- JAXA has re-examined Level 1 calibration carefully over 2yrs, and we determined new calibration factors.
- In order to determine the calibration factors, DPR external calibration was conducted more than 50 times after GPM core observatory was launched.
- There are many re-examined items for the calibration. For example, recalibration of Active Radar Calibrator(ARC) itself, reconfirmation of radar parameters such as beam width, pulse width, and so on.
- TRMM/PR's calibration was also re-examined and its new calibration factors were determined.
- The calibration change was endorsed at JPST telecon on Oct.19(JST).

Calibration change of GPM/DPR and TRMM/PR(2/2)

Concept of the calibration change

- JAXA regards the latest DPR calibration with the well-calibrated instruments most reliable.
- Since σ^0 statistics under certain conditions is very stable, we use σ^0 statistics to relate DPR (KuPR) and PR calibration.
- Calibration results with the active radar calibrators (ARCs) are used in Level1 processing. Consistent σ^0 statistics is realized by introducing an adjustment factor in Level2 processing.

Changes of Z_m, σ0, rain rate (See Table.1)

Table.1 Changes from current version to new version

Algorithm	Level 1		Level 2				
Variable / Sensor	Z_m	σ^0	Adjustment Factor (A)	Adjusted Z_m (=Z_m -A)	Adjusted σ^0 (=σ^0 -A)	Rain Rate*2 (2km height)	
						Ocean	Land
KuPR	+1.7dB	+1.7dB	0.0dB	+1.7dB	+1.7dB	+15.9%	+16.3%
PR(B-side)	+1.9dB*1	+1.9dB*1	+0.2dB	+1.7dB	+1.7dB	+16.9%*3	+15.7%*3

*1: DPR V5 calibration is fixed, but PR V8 calibration is still under final adjustment in L1 algorithm.
*2: Numbers are preliminary results because V5 L2 algorithm is not final yet.
*3: Numbers are effect of calibration coefficient change.

[Latent Heating] The first GPM latent heating product was released on March 2016

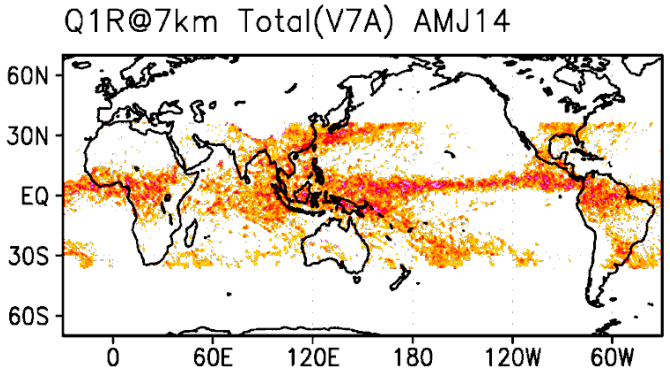
Comparison of latent heating products between TRMM/PR and GPM/DPR by the SLH algorithm (Shige et al. 2004) during Apr., May, Jun. 2014.

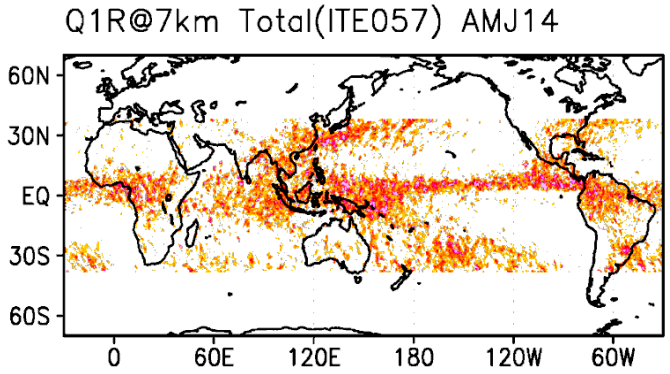
[K/day]

TRMM PR V7A

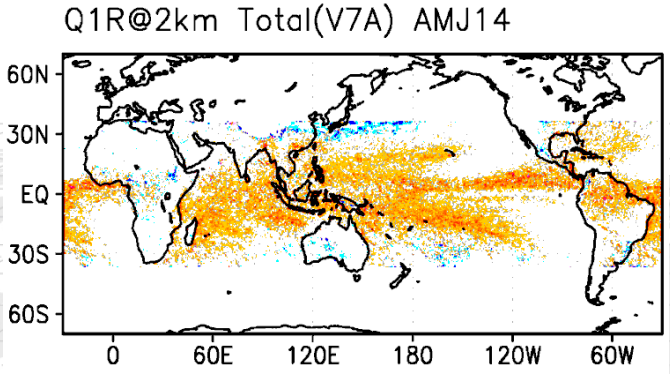
GPM DPR V04

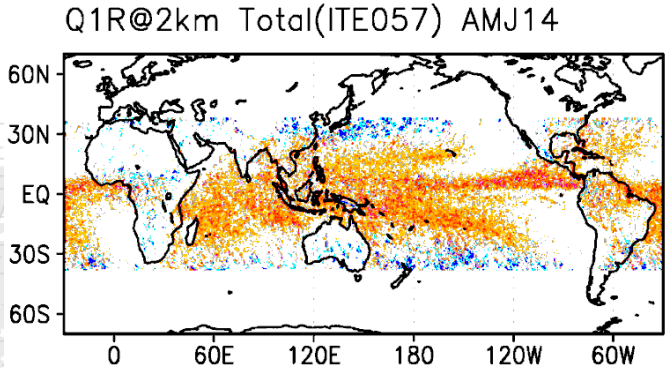
7km





2km



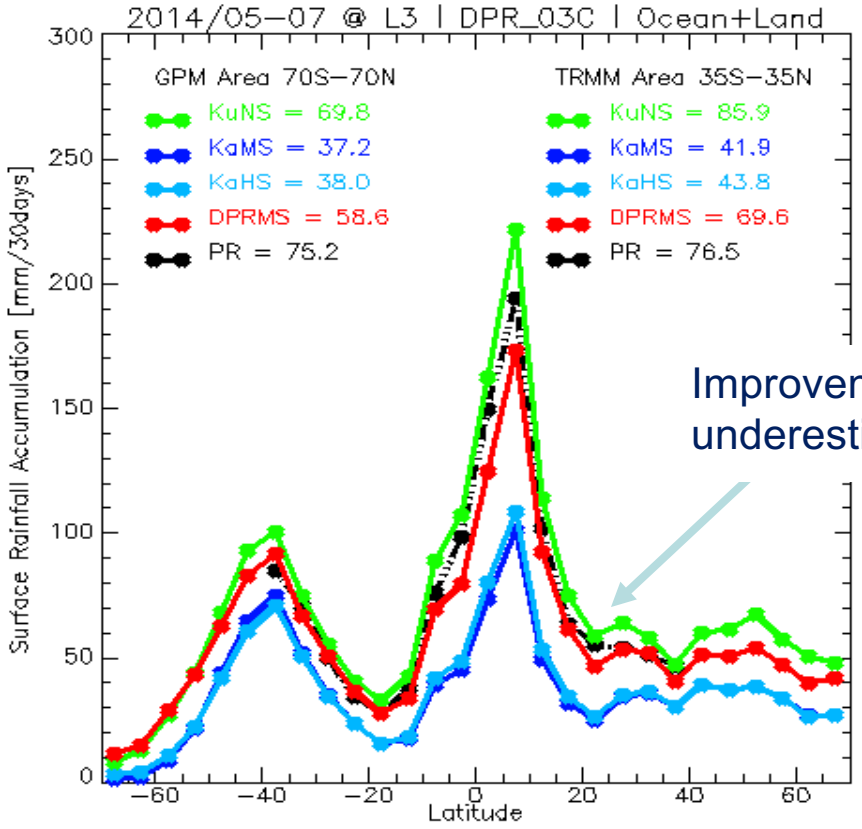


→ **Long-term latent heating observations using TRMM and GPM**

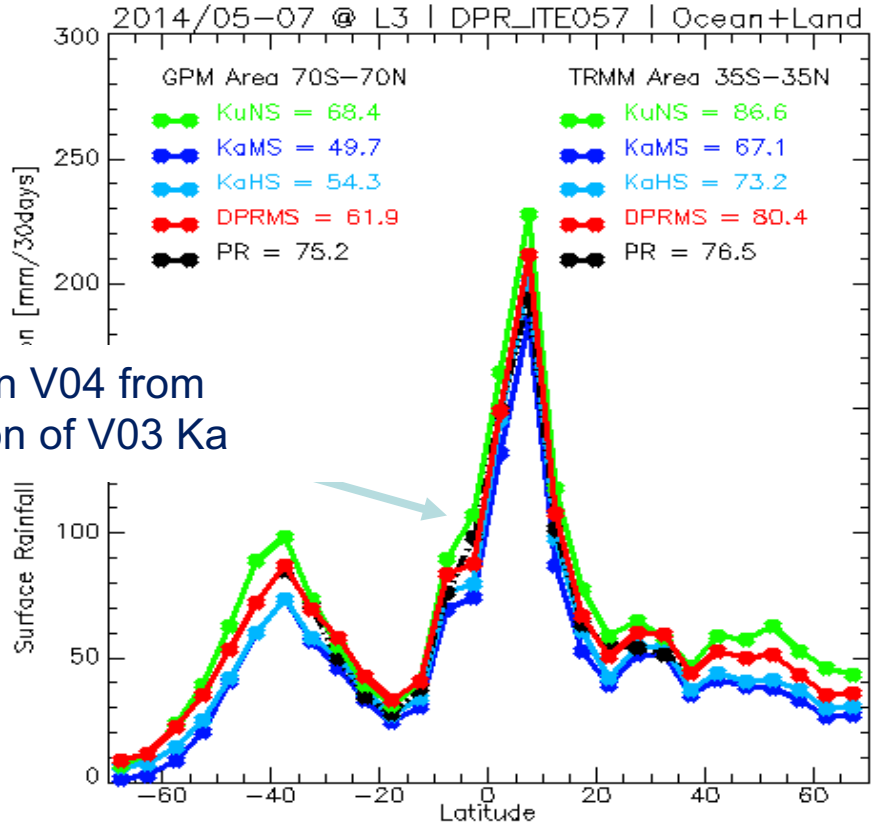
Version 4 GPM/DPR product released in Mar. 2016

Unconditional zonal mean of surface precipitation (May-July 2014)

V03B



V04



Improvement in V04 from underestimation of V03 Ka

→Underestimation of V03B Ka was improved in V04.
The products were more consistent in V04.

Minimum success criteria of the DPR

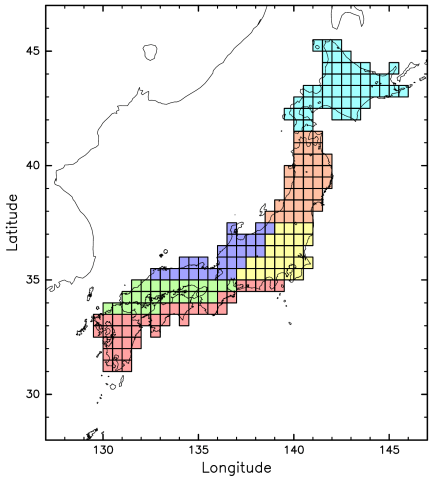
- Success criteria of the DPR in the JAXA was defined as following.
- Here, results of the “minimum success” using JMA AMeDAS rain gauge network are shown.

Minimum success:
~ ±15% difference achievement of annual rainfall observed by between DPR and AMeDAS rain gauge network.

Full success:
~ ±10% difference achievement of long term-averaged rainfall observed by between DPR and some rain gauge/radar networks in the world.

Verification of the minimum success

- Data: V4 (ITE049)
- Period: Apr. 2014 to Mar. 2015 (12 months)
- Rain-only (T_{sfc}>6 deg.C.)
- DPR-L2 MS



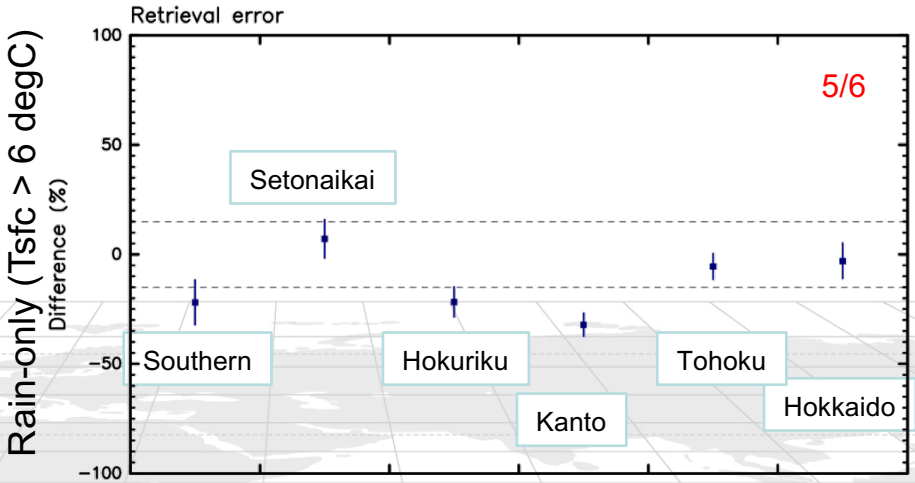
6 areas:

- Hokkaido
- Tohoku
- Kanto
- Hokuriku
- Setonaikai
- Southern

- Bias errors =

$$\frac{\text{DPR} - \text{AMeDAS (overpass only)}}{\text{AMeDAS (overpass only)}} \times 100(\%)$$

- Error bars: variances of DPR rain (footprint) within the grid box



➢ Half of the areas (mean), and 5/6 areas (considering variances) achieved the errors less than 15% → The achievement of the minimum success was verified!

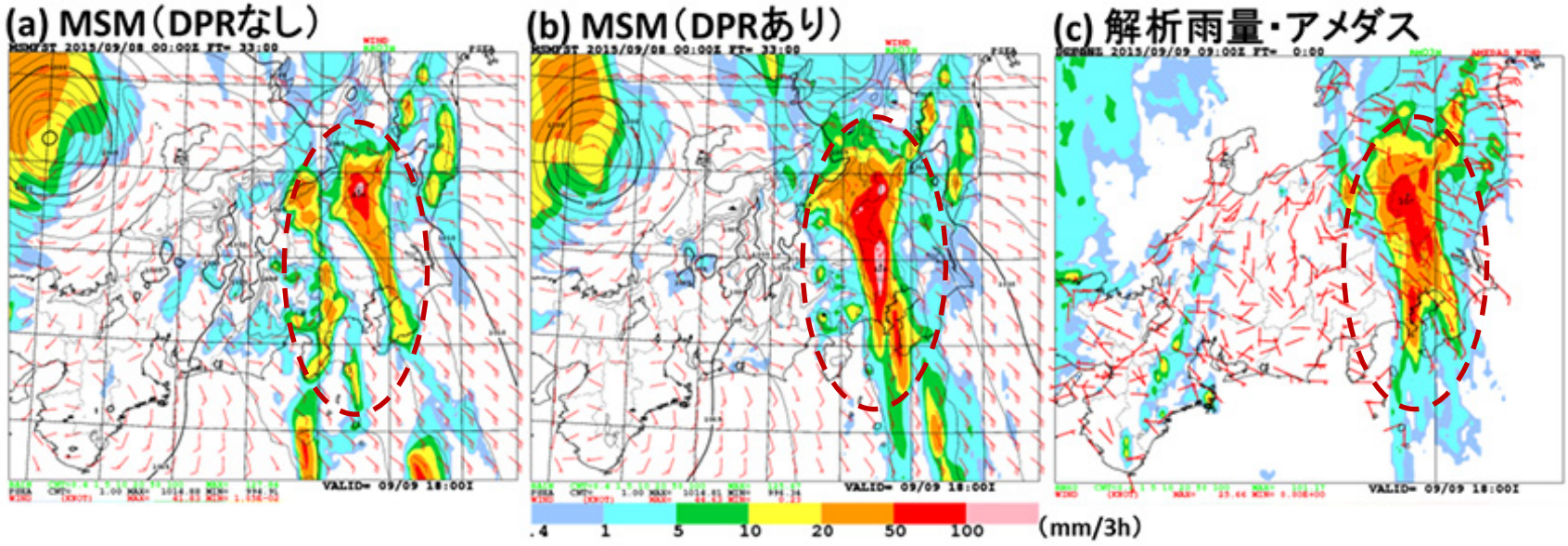
GPM/DPR Data Assimilation in the JMA NWP system

The Japan Meteorological Agency (JMA) started the DPR assimilation in the meso-NWP system and the GMI assimilation in the meso- and global-NWP system on March 24 2016. → Word's first "operational" assimilation of spaceborne radar data in the NWP system of meteorological agencies!

a) 33-hour prediction without the DPR

b) 33-hour prediction with the DPR

c) Observation



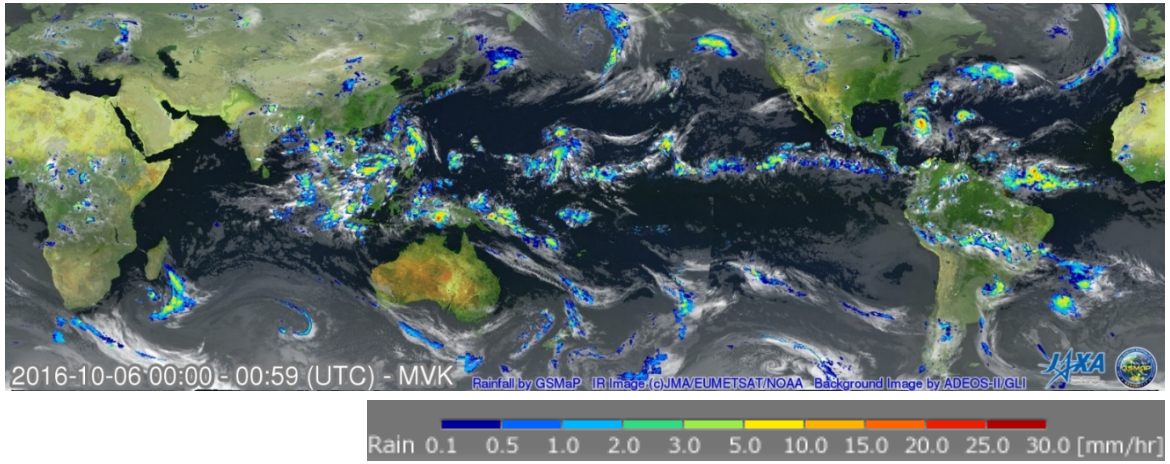
Provided by JMA

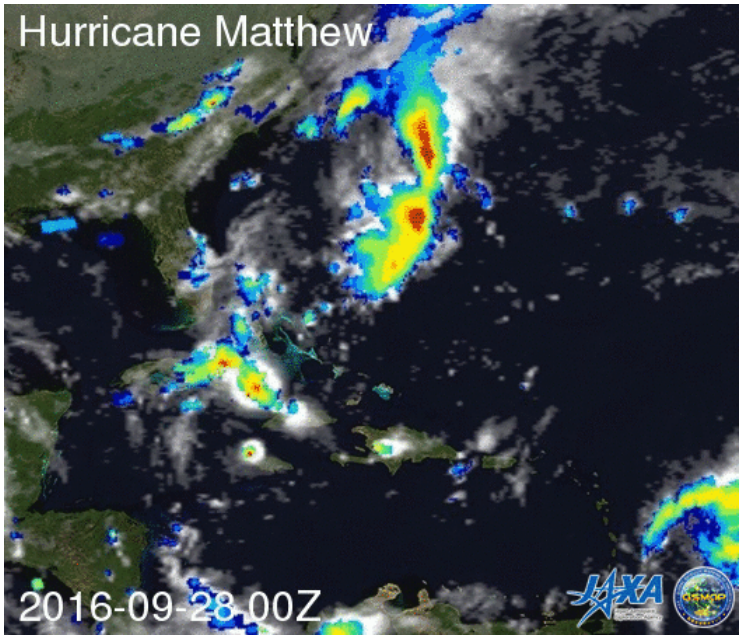
- **Example of Kanto-Tohoku Heavy Rainfall in 2015**
- **Improvements in water vapor analysis accuracy over the ocean**
- **Improvements in rainfall forecast accuracy**

Global Satellite Mapping of Precipitation (GSMaP)

http://sharaku.eorc.jaxa.jp/GSMaP/

[Oct. 2016: Hurricane Matthew case]

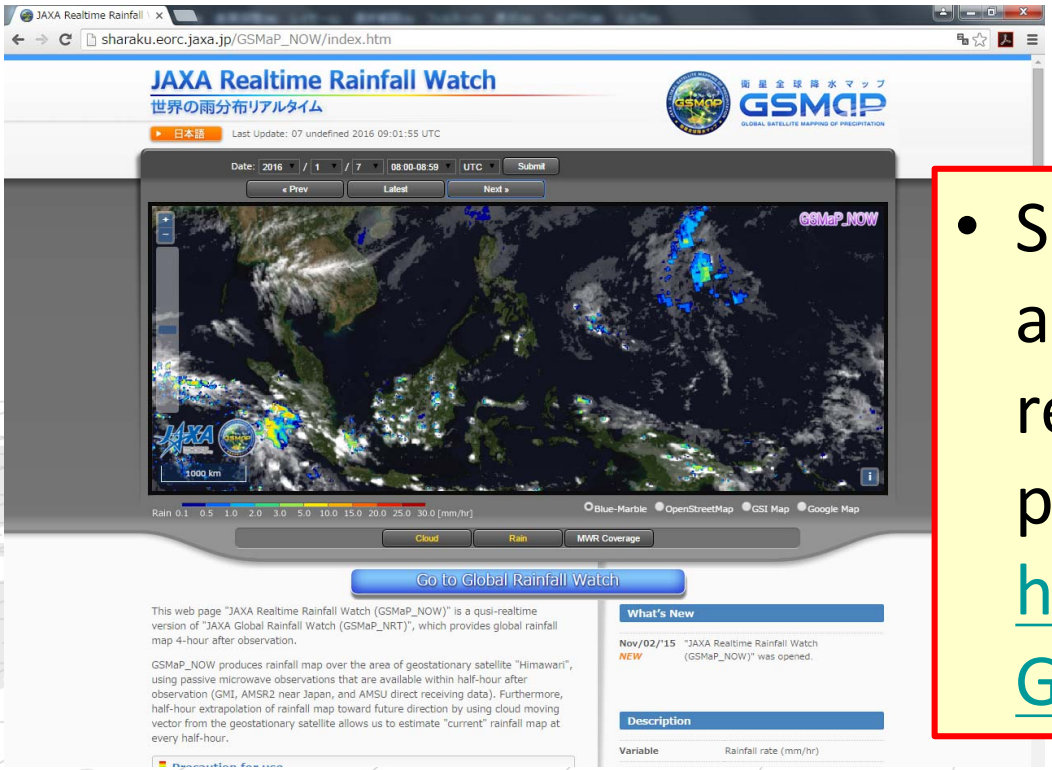




- GSMaP is a blended Microwave-IR product and has been developed in Japan toward the GPM mission.
  - U.S. counterpart is “IMERG”
- **“GPM-GSMaP” data (algorithm V6) were released on Sep. 2014.**
  - GPM-GSMaP data since Mar. 2000 period was reprocessed as reanalysis version (GSMaP_RNL), and was open to the public on Apr. 2016.

GSMaP real-time version (GSMaP_NOW)

- To reduce latency from 4-hr to “quasi-realtime”
  - Using data that is available within 0.5-hour (GMI, AMSR2 direct receiving data, AMSU direct receiving data and GEO Himawari-IR) to produce GSMaP at 0.5-hr before (observation).
  - Applying 0.5-hour forward extrapolation (future direction) by cloud motion vector to produce GSMaP at current hour (just now) → “GSMaP_NOW”.

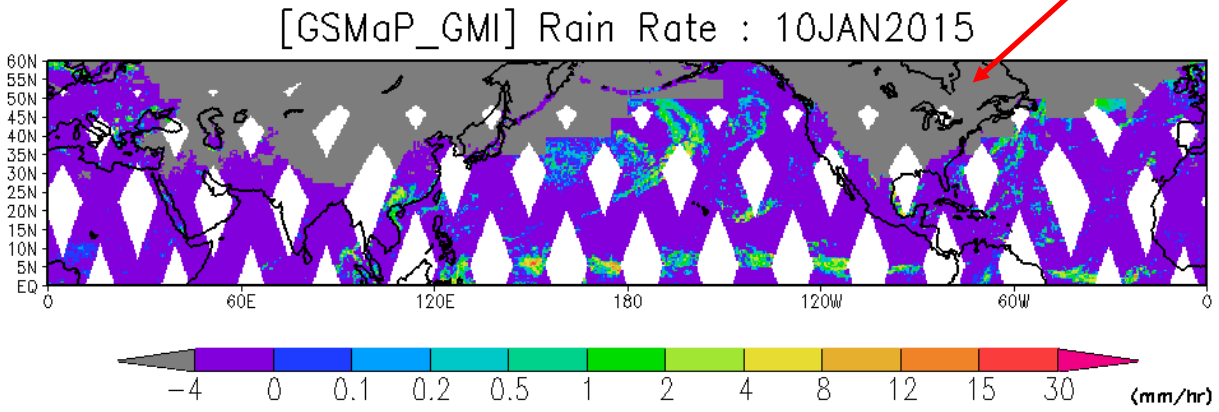


- Since Nov. 2015, web site and data (GEO-Himawari region) are open to the public from http://sharaku.eorc.jaxa.jp/GSMaP_NOW/

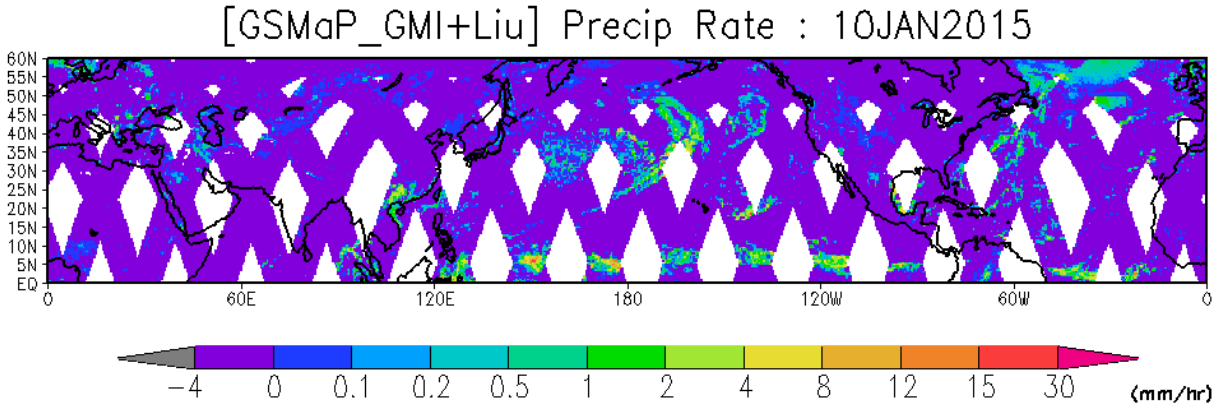
GSMaP coming plan: Snowfall estimation with Prof. G. Liu's method

- In the current GSMaP, there are no snowfall estimates.
- →We're now trying to integrate the snowfall estimation method by Prof. G. Liu (Florida State University) into the GSMaP algorithm.
- New version product (Product version: V04, Algorithm Version: V7) will be released on Dec. 2016.

GSMaP



GSMaP
+
Liu



- Snow-Rain Separation method (Sims and Liu 2015)
- Snowfall estimation (Liu and Seo 2013)

Upcoming events

- JpGU-AGU Joint Meeting 2017
  - May 20-25, 2017, Makuhari Messe, Chiba, Japan
  - “Satellite Earth Environment Observation” (conveners: R. Oki, G. Skofronick Jackson, P. Chang, Y. Honda)

- 6th GPM Asia Workshop on Satellite Precipitation Data Utilization
  - 18-19 January, 2017, Thai Meteorological Department, Thailand

- JAXA joint PI Workshop 2017
  - January 23-27, 2017, Tokyo, Japan

Summary

- The Japanese PMM Science Team started in Apr. 2013 for three-year period.
  - 41 proposals for the 8th RA (JFY2016-2018)
- GPM products V04 were released to the public on Mar. 2016.
  - DPR, GMI, DPR/GMI combined algorithms were updated.
  - The first GPM latent heating product (only in TRMM region) was released.
- Calibration change of DPR L1 is scheduled on Mar. 2017.
- Global rainfall map product (GSMaP)
  - GSMaP data (algorithm version V6) are now available since Mar. 2000.
  - GSMaP realtime product (GSMaP_NOW) was open to the public on Nov. 2015 in the domain of GEO-Himawari (JMA meteorogical satellite).
  - GSMaP major algorithm updates will be scheduled on Dec. 2016.
- Japanese validation activity
  - Japan Meteorological Agency (JMA) rain gauge network, etc.
- Japanese application activity
  - Utilization of GPM data in the numerical weather prediction (NWP) system, etc.